

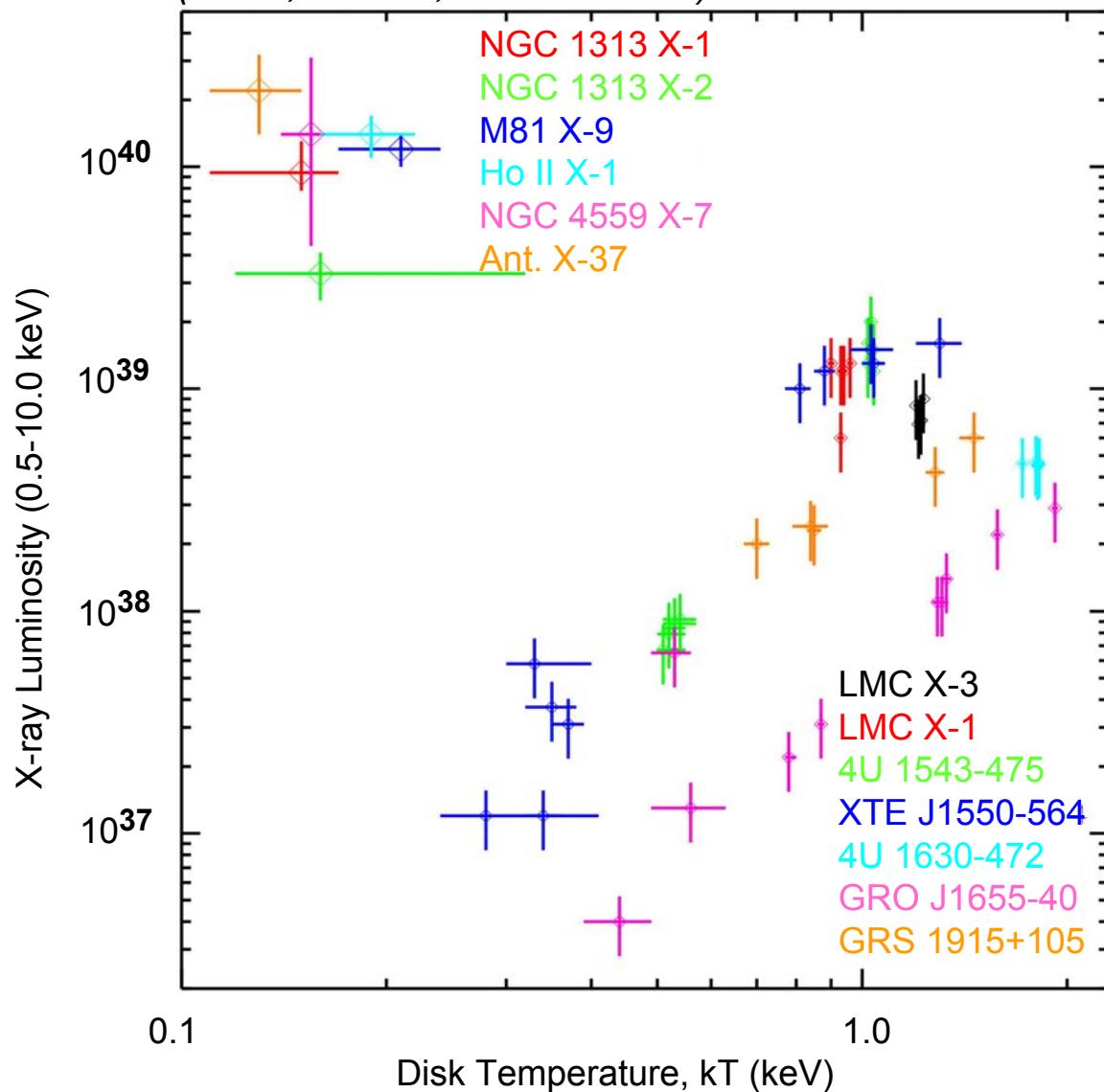
Con-X Science with Galactic Black Holes and ULX/IMBHs

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First, the easy part:

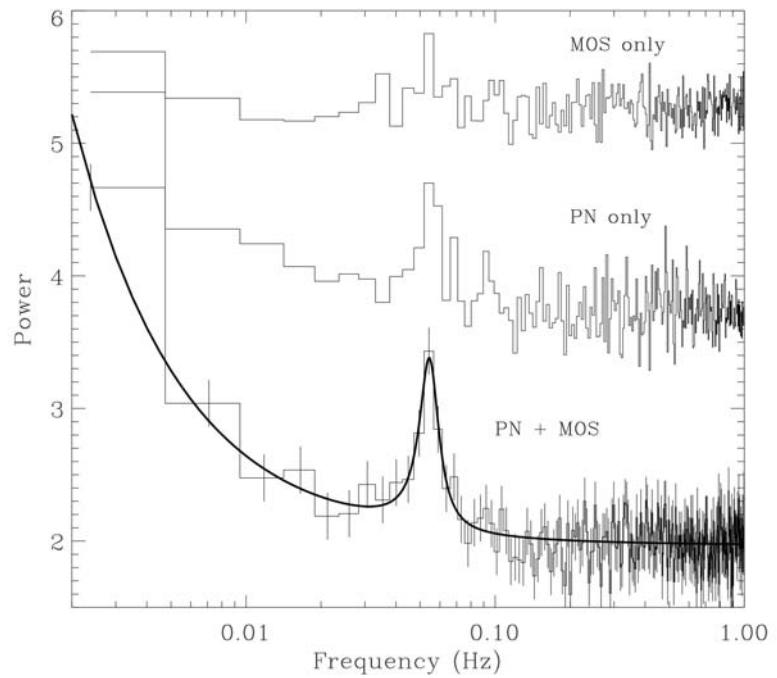
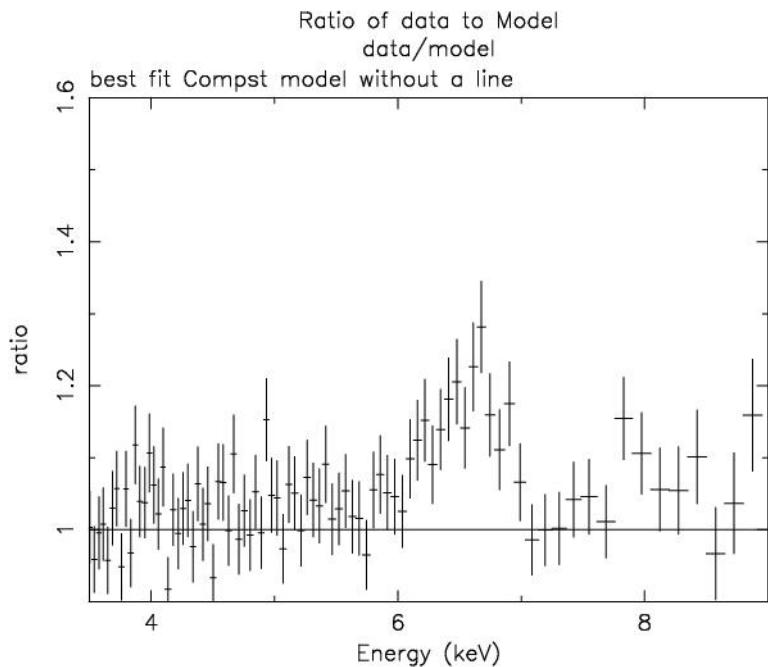
Con-X will be excellent for ULXs/IMBHs

(Miller, Fabian, & Miller 2004)



How to do better:

(*Strohmayer & Mushotzky 2003*)



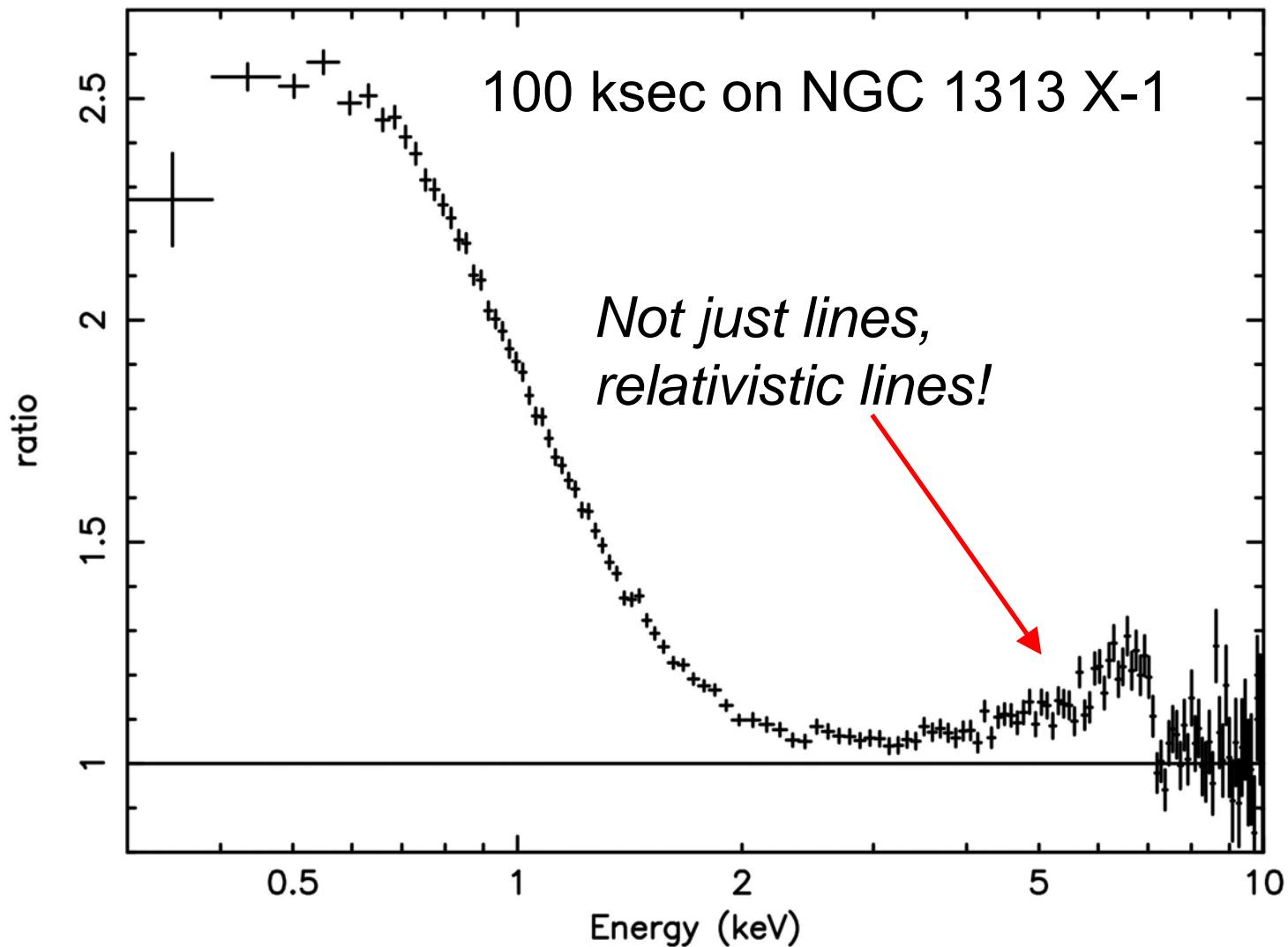
9-Jan-2003 15:41

The QPO Equation (see vdK95):

$$N\sigma = 0.5 * [s^2/(s+b)] * (\text{rms})^2 * \sqrt{T/\Delta\nu}$$

- For a QPO of a given q , S/N grows linearly with count rate (effective area) for $b \ll s$.
- With Con-X, then, QPO significances will be enhanced by $R = A_{\text{con-x}} / A_{\text{xmm}}$.
 $R = 7-8$ at 1-2 keV, 4-5 at 6 keV.

Doing better with Con-X:



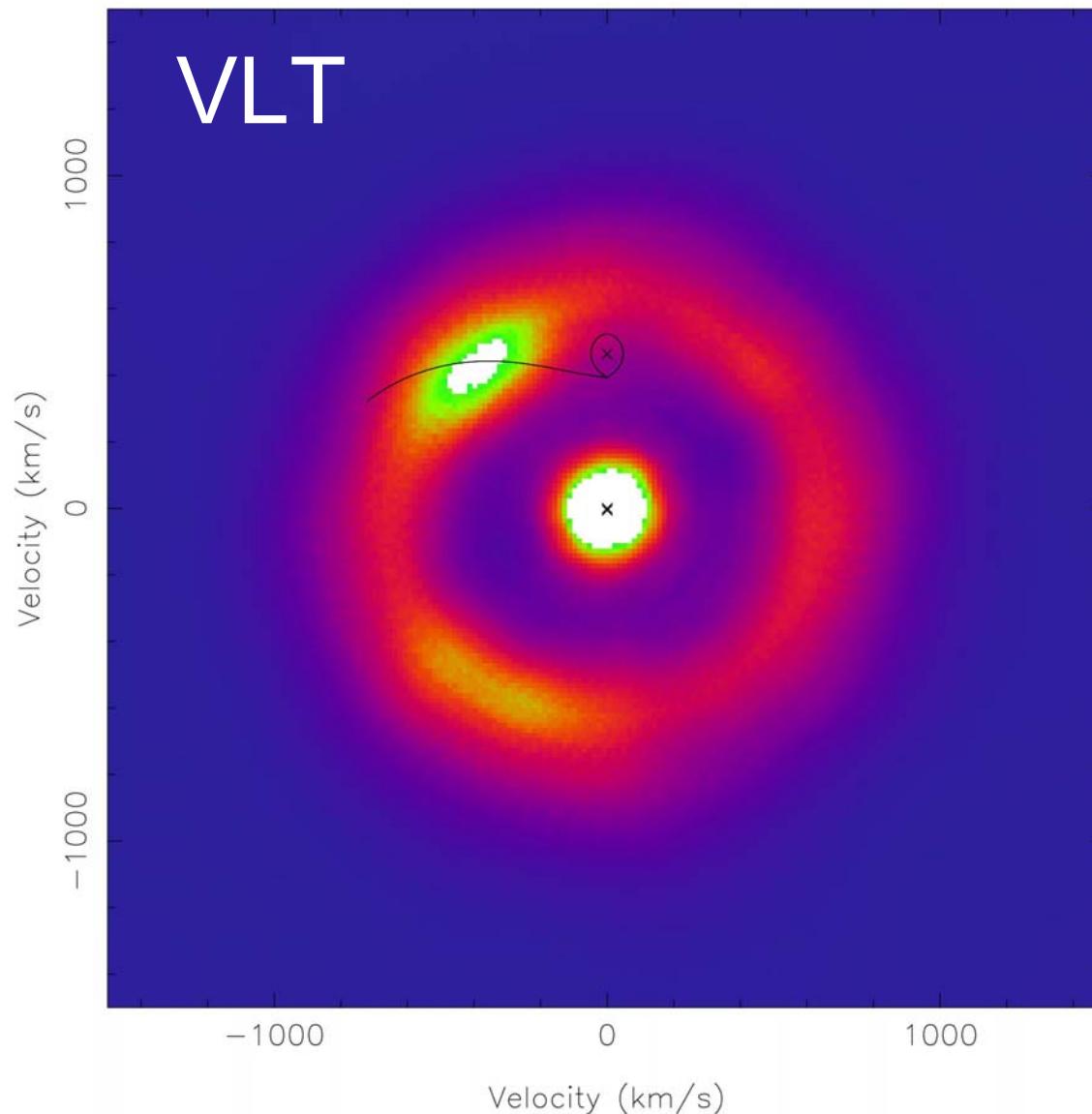
Relative Impact of Constellation-X:

Local AGN in which reverberation mapping will work:	6-8
Galactic black holes in which GR effects can be probed over a 10 year mission:	10-15
ULXs with some hint of IMBH nature, on which Con-X can be decisive with XMM-like resolution:	20-30

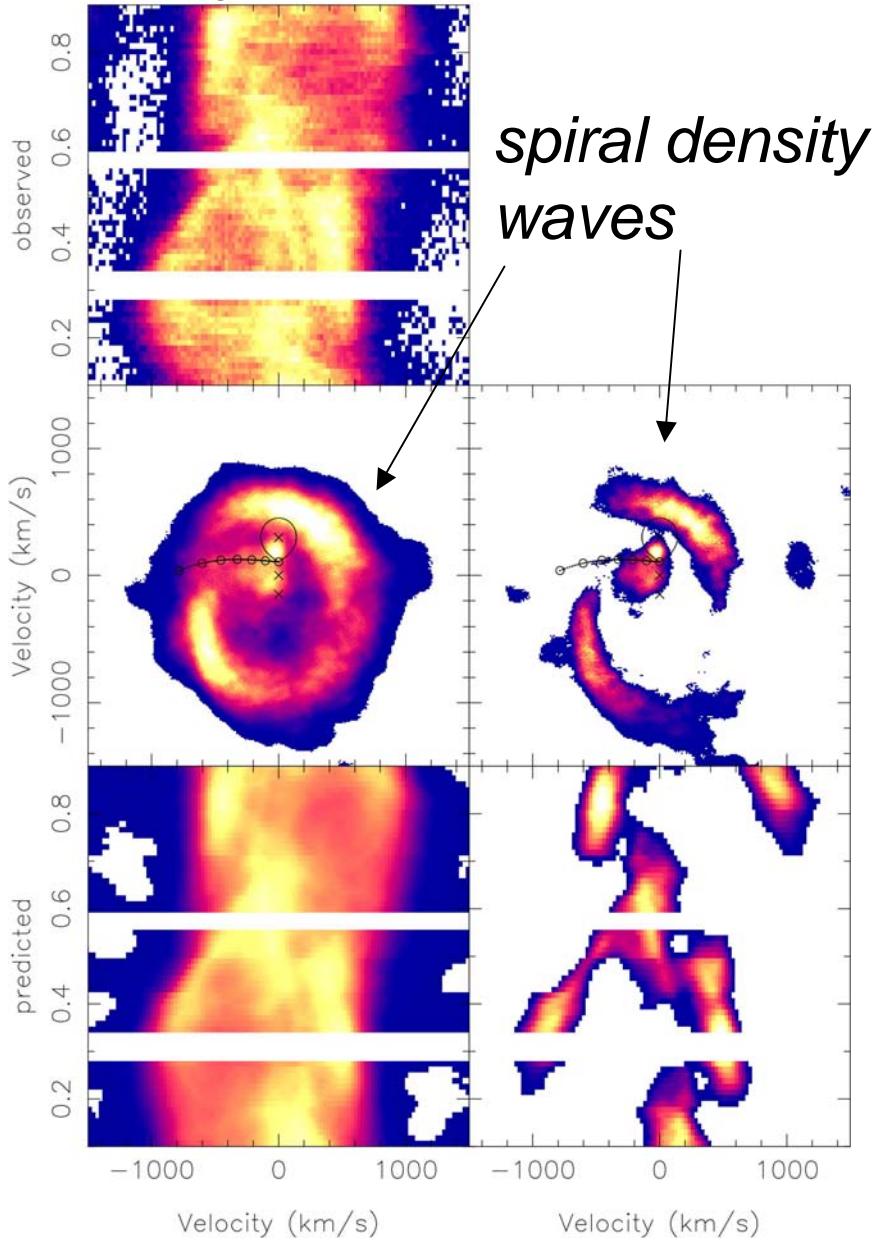
Astrophysicists have a bad habit of observing things to the same S/N.

But when we do observe bright targets with large telescopes, we really learn.

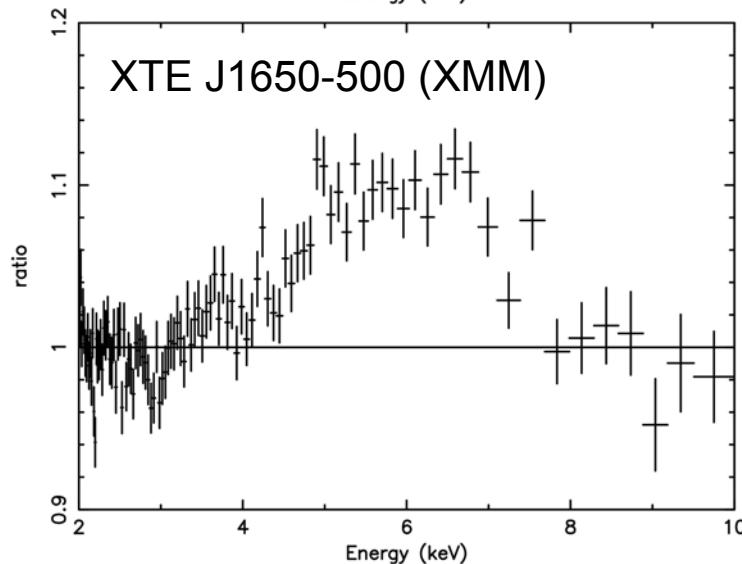
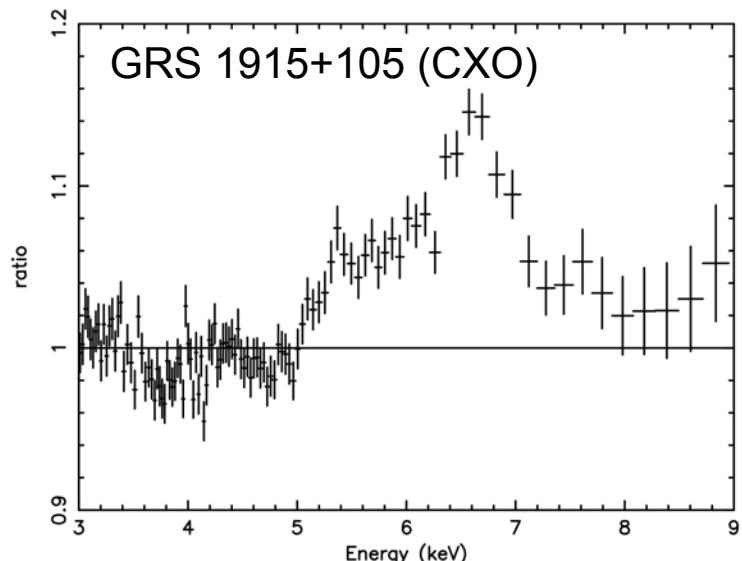
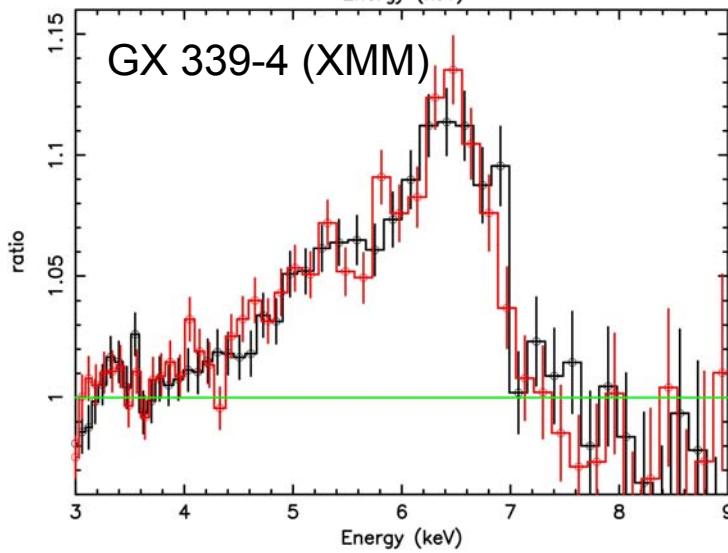
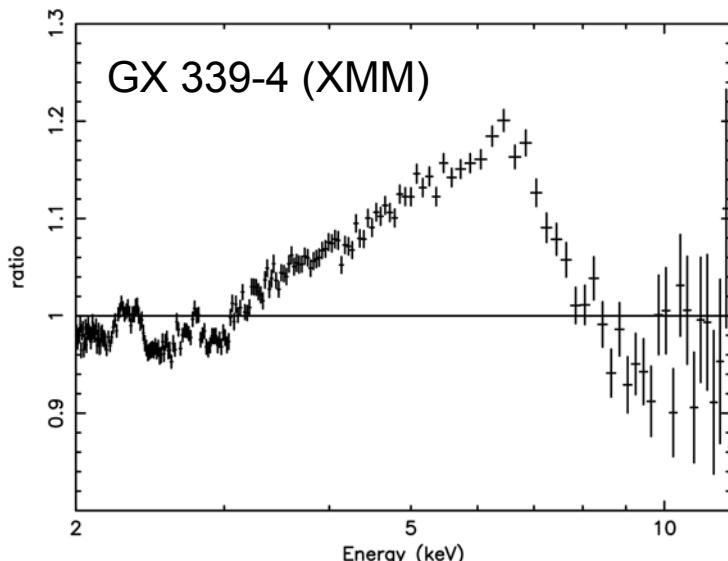
*Con-X needs to be able to observe
 $F_X = 1$ Crab sources, high throughput.*



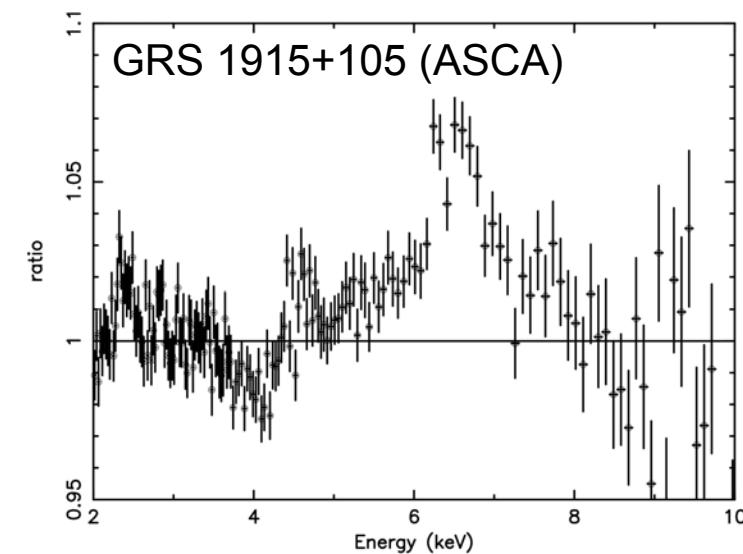
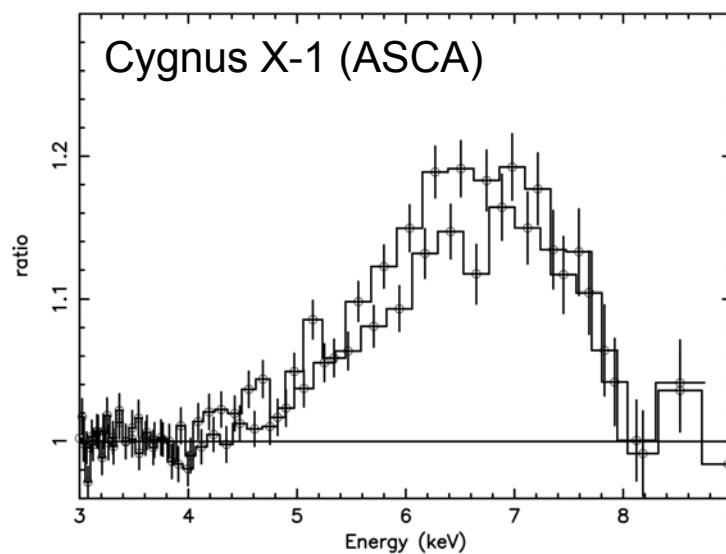
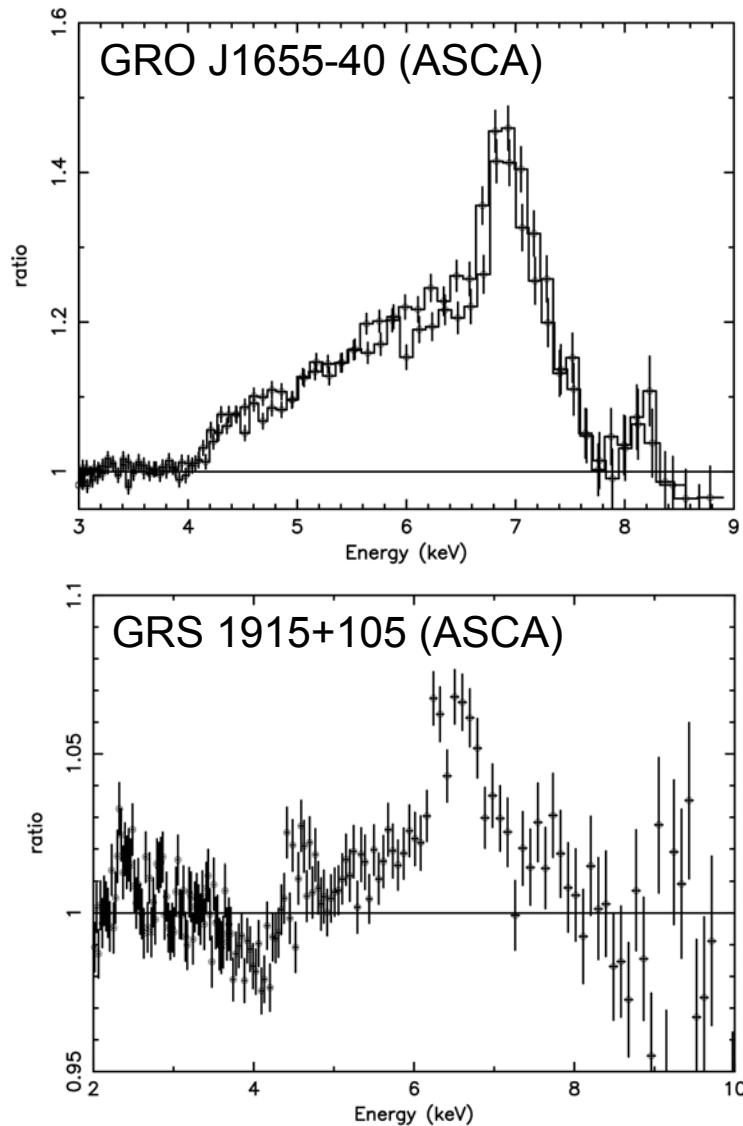
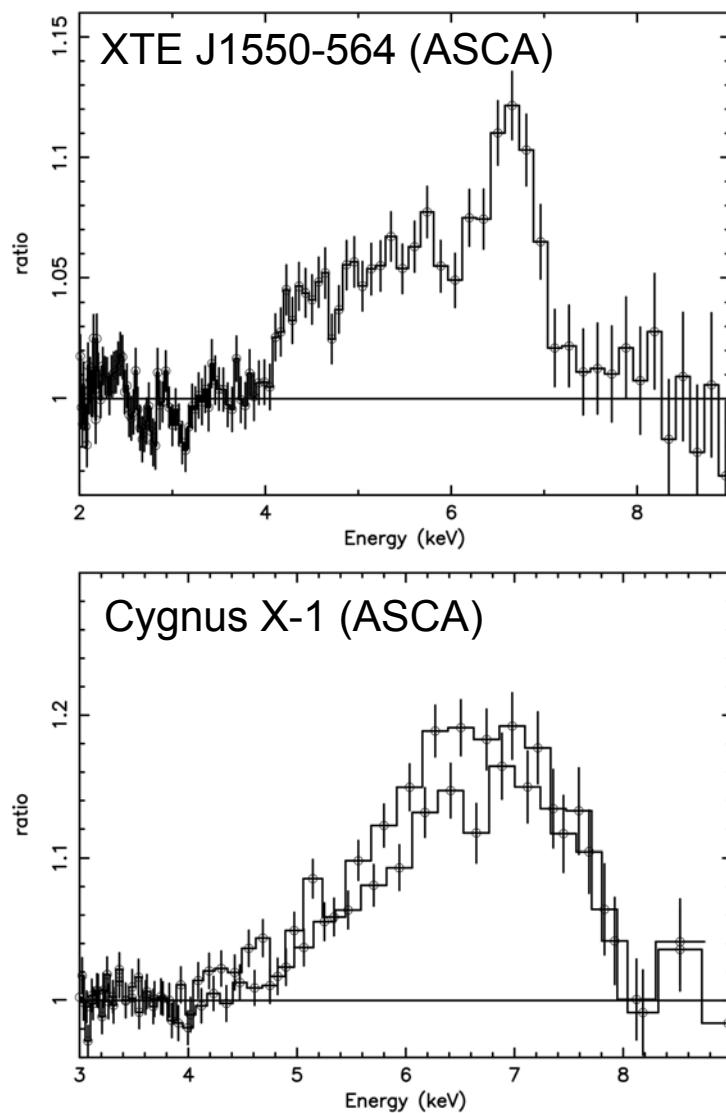
IP PEG Hell(4686)
(Steeghs et al.)



Iron Lines in Galactic Black Holes

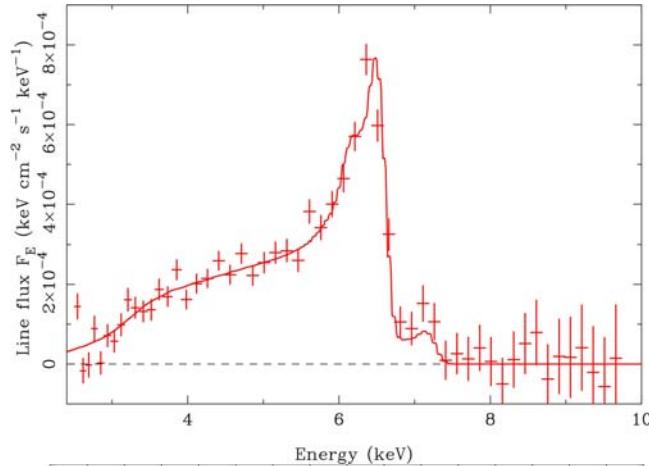


More Lines in Galactic Black Holes

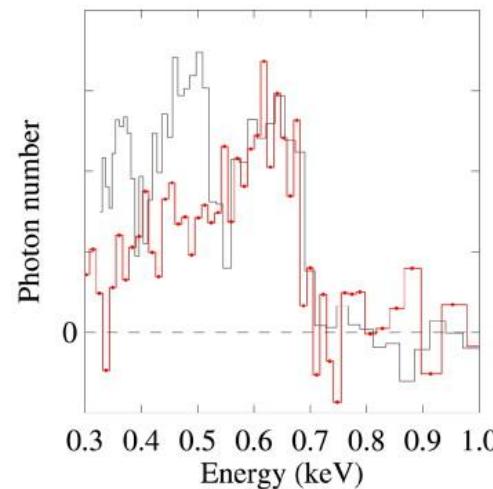
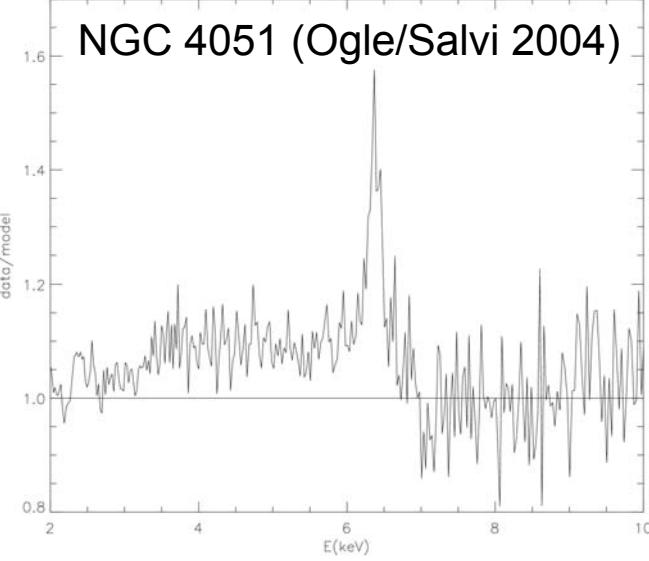
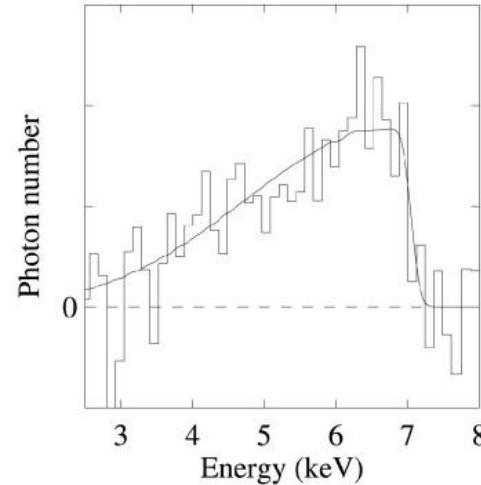


Iron Lines in AGN

MCG-6-30-15 (Fabian 2002)

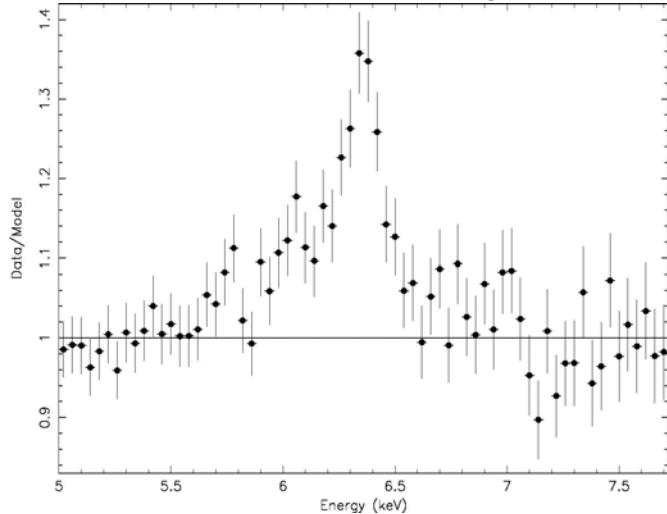


Mrk 766 (Mason 2003)

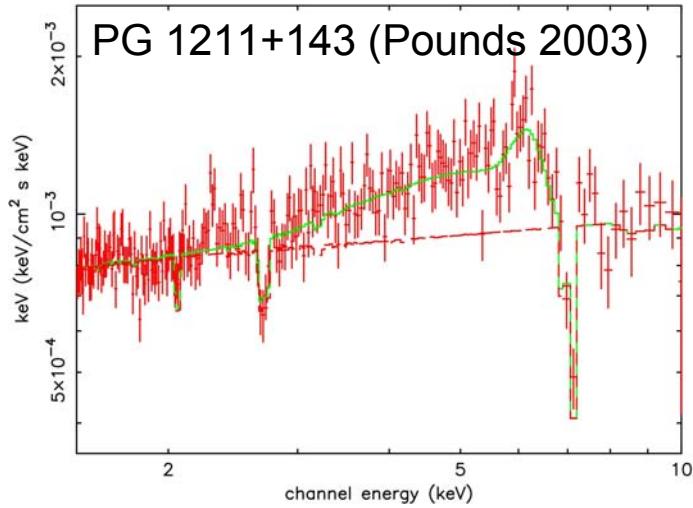


More Lines in AGN

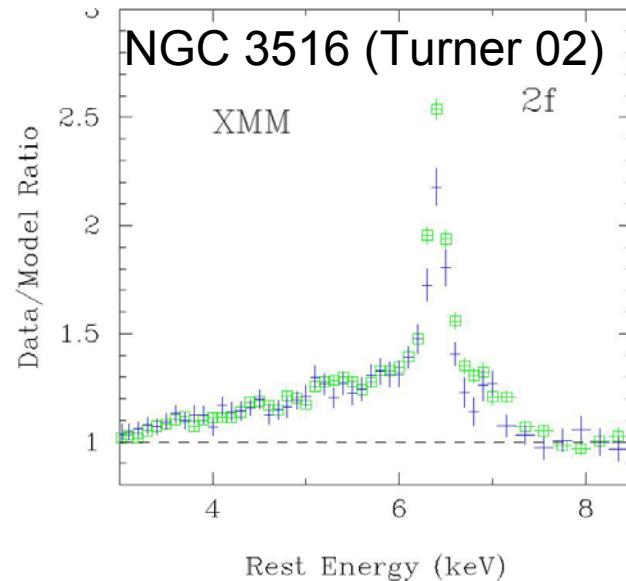
MCG-5-23-16 (Dewangan 2003)



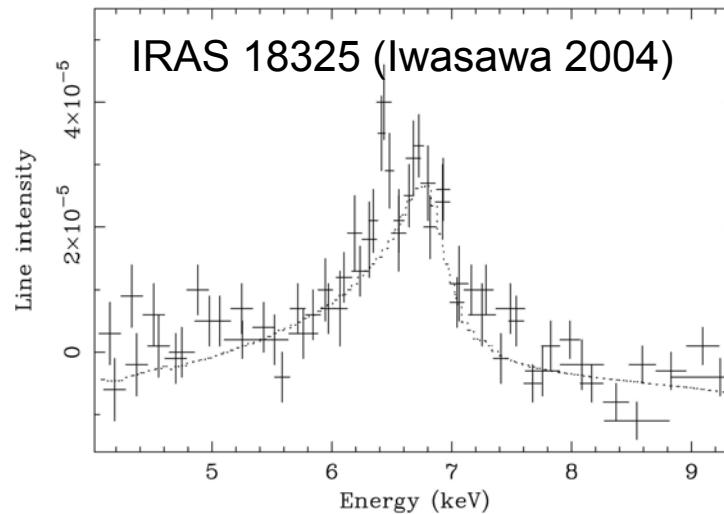
PG 1211+143 (Pounds 2003)



NGC 3516 (Turner 02)



IRAS 18325 (Iwasawa 2004)



Let us not hang all of our GR hopes on AGN.

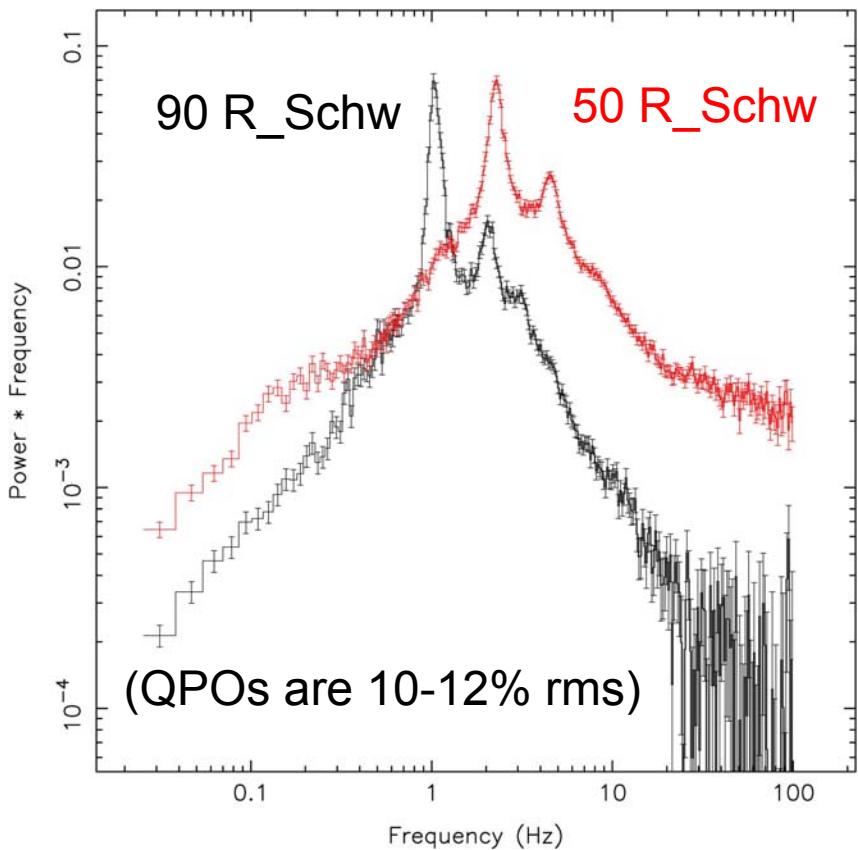
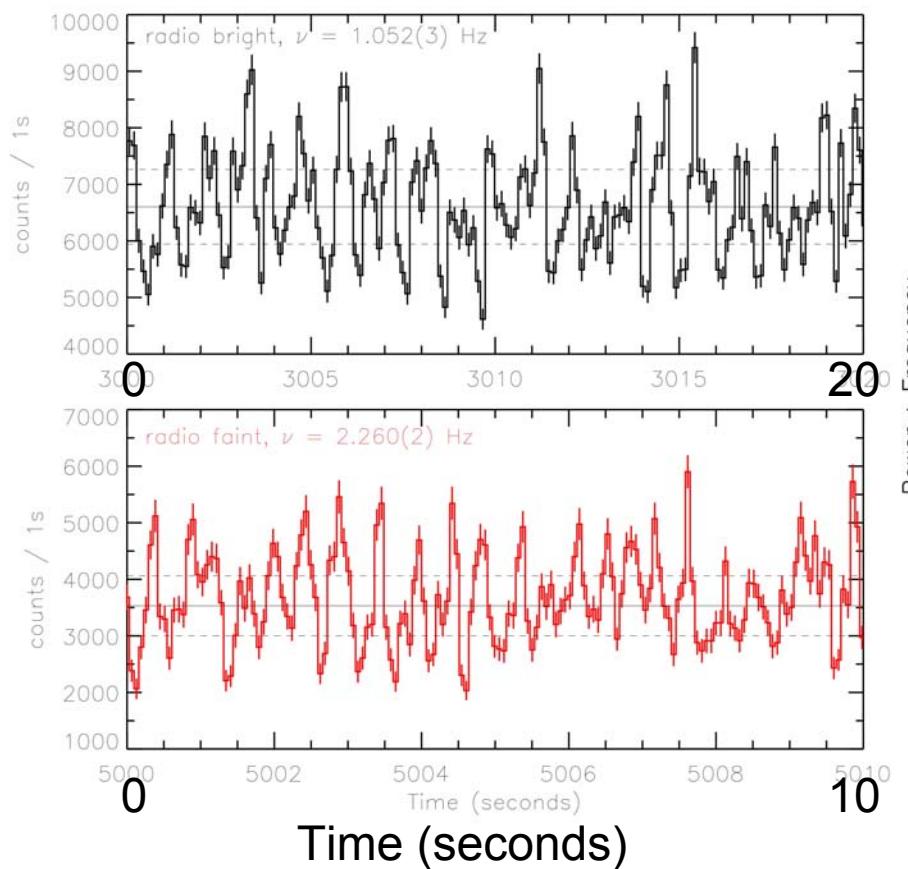
Galactic Black Holes are simpler.

More prominent Fe K lines. + QPOs

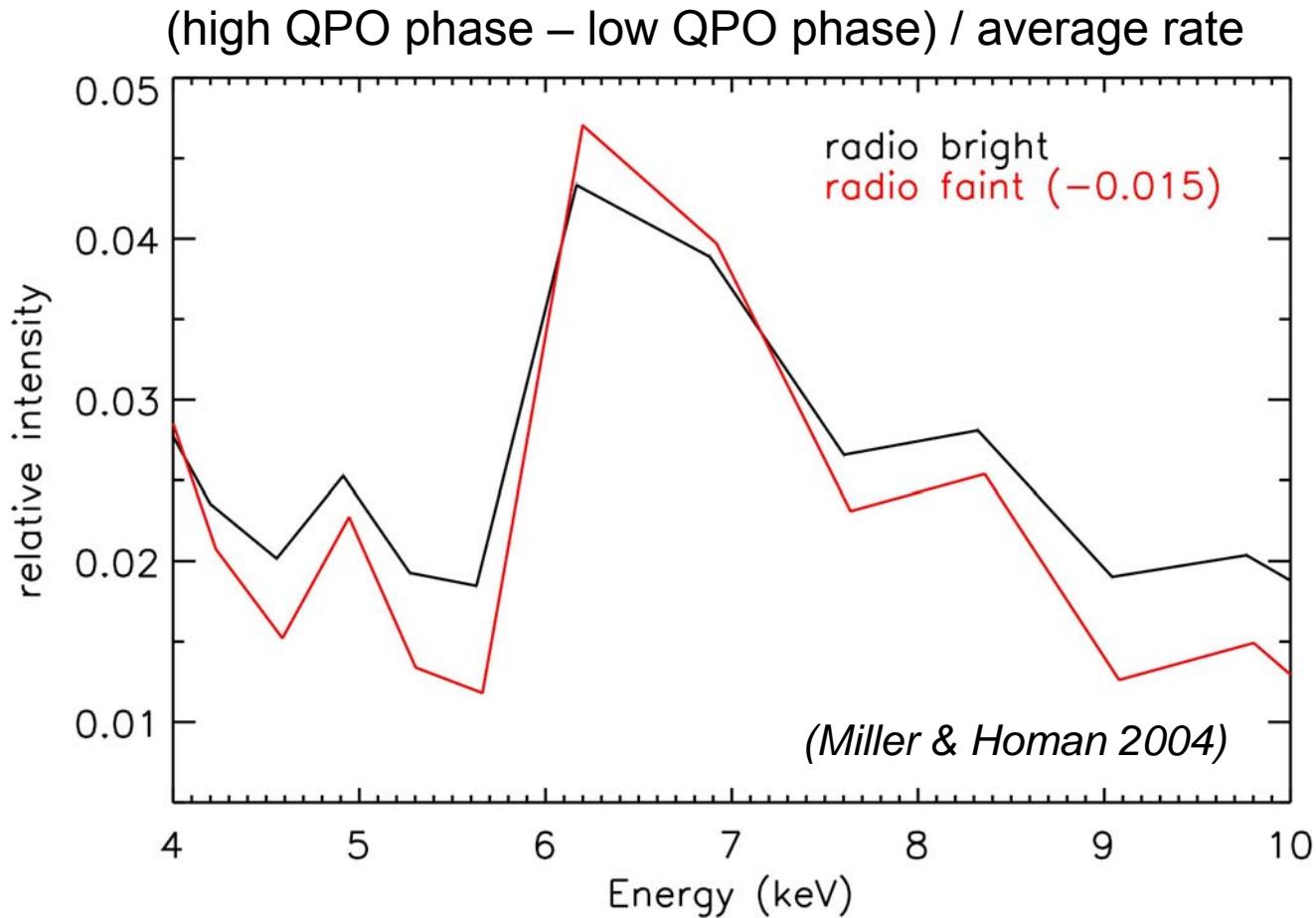
And for that reason, we can do some extraordinary things with relative ease.

QPOs in GRS 1915+105 ($M = 14 \text{ Msun}$)

(Miller & Homan 2004)



Difference Spectra

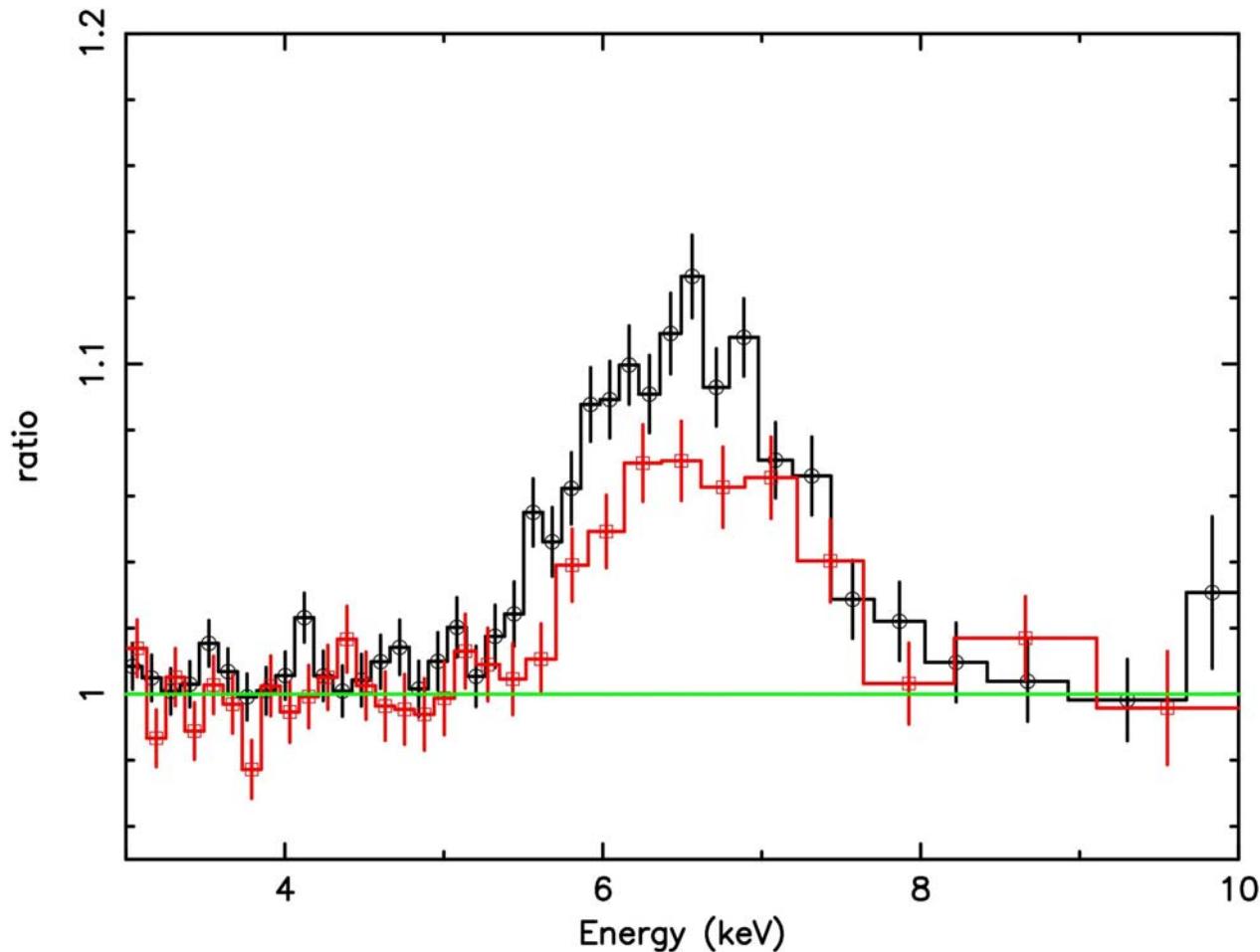


The FeK—QPO Connection and Con-X

- Two measures of radius from peaked features:
 - 1) Direct line fitting
 - 2) QPO frequency
- *Radius is over-constrained.*

This is how to really push on GR near the BH.
(and disk models, and QPOs, and jet launching)

100 cycles (100 sec.) with Con-X @ 2m²



Instrumental Impacts

Galactic Black Holes, NSs

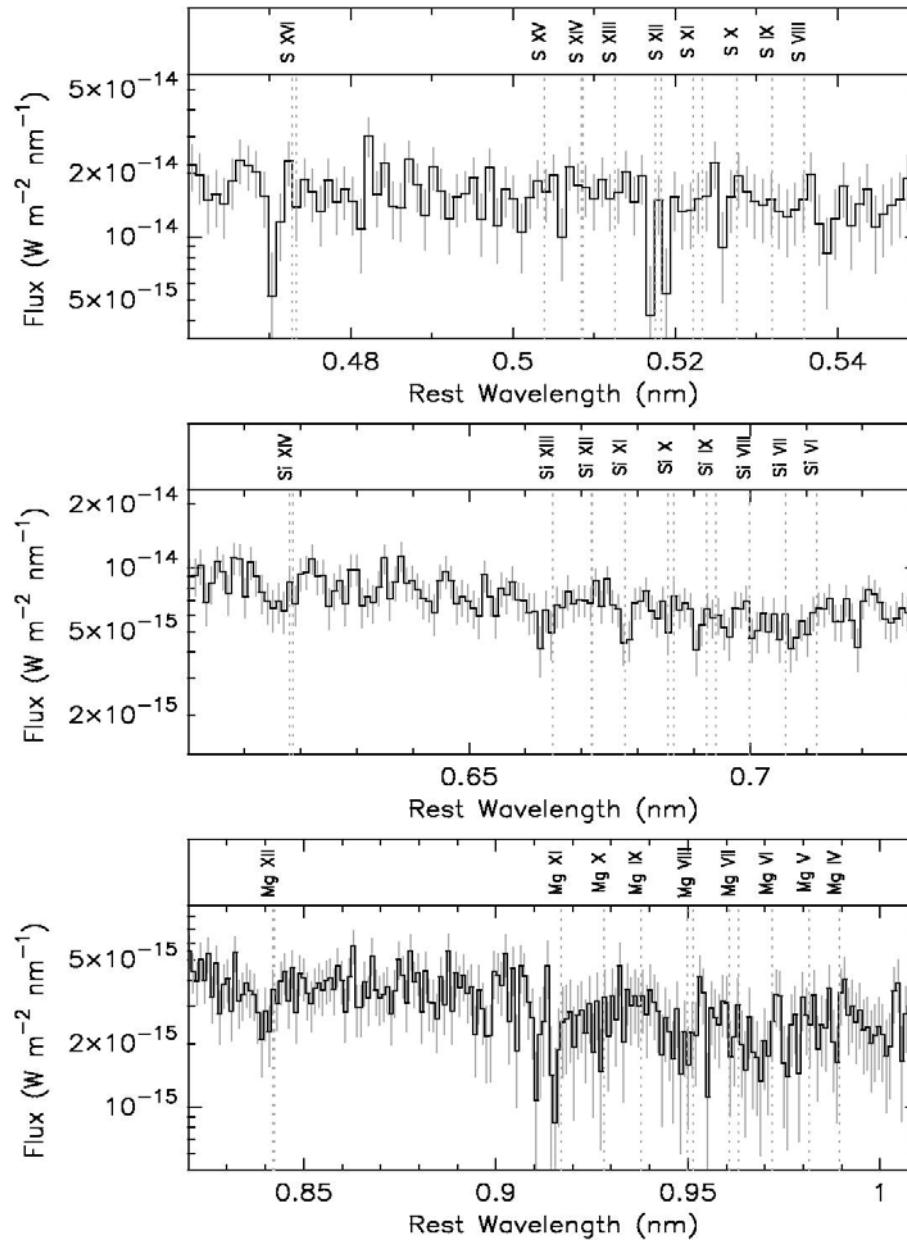
- Must be able to observe sources with $F \sim 1$ Crab
- High throughput (low deadtime, high telemetry)
- $E_{\text{max}} \sim 60\text{-}100$ keV is better than 30-40 keV

ULXs/IMBHs

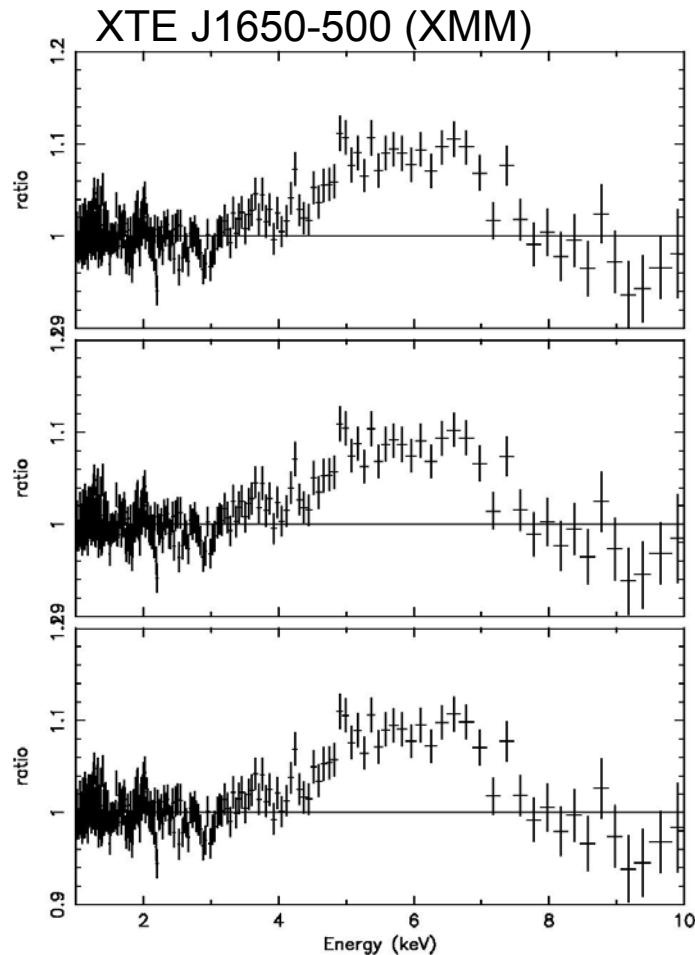
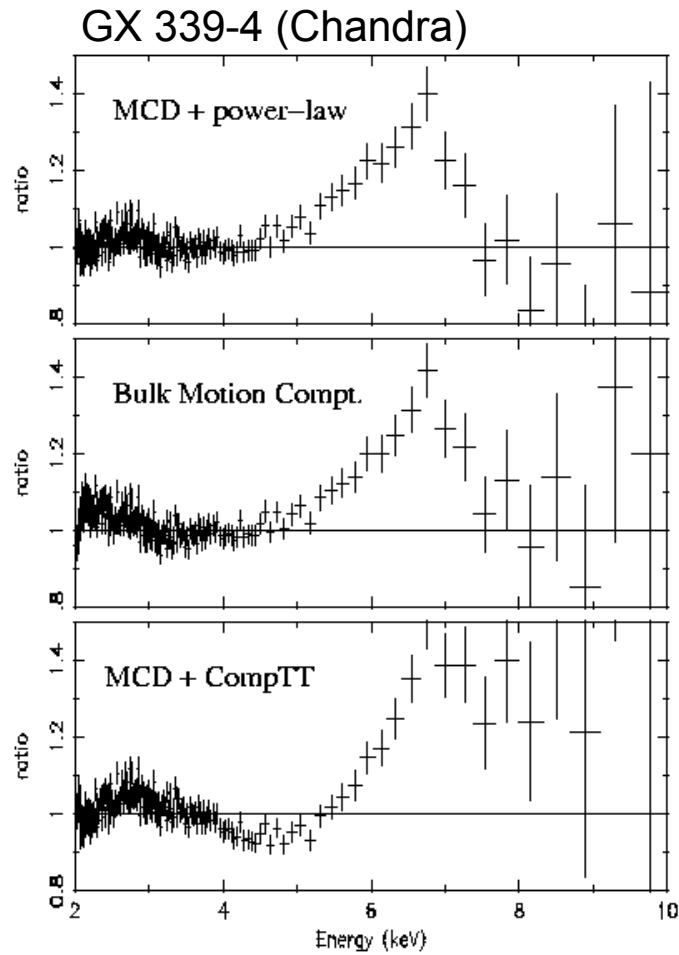
- PSF no worse than XMM, 3-5 arcsec even better
- FOV like 1 ACIS chip or the central MOS CCDs

extra slides

NGC 3516



Dependence on Continuum Models



Mdot (wind) > 6 Mdot (Edd)

Use accretion luminosity: $L_a = 0.1 \text{ Mdot}_a c^2$
Wind mass flow rate: $\text{Mdot}_w = 4 \pi f r^2 m_p v$
(f is solid angle, expect $f \sim 1$, Ionization param, if X-rays ionize wind, $\xi = L_a / n r^2$)
So: $\text{Mdot}_w / \text{Mdot}_a = 1000 f (v_9) (\xi_3)^{-1}$
 $(v_9 = 10^9 \text{ etc})$

(this is absurd unless f is very small or ξ very high, and if ξ is very high the wind density is low and therefore optically thin).

$$\begin{aligned}L_w / L_a &= 0.5 \text{ Mdot}_w v^2 / \text{Mdot}_a c^2 \\L_w / L_a &= 5 (\text{Mdot}_w / \text{Mdot}_a) (v/c)^2\end{aligned}$$

Now for $\tau_T > 1$ $\tau_T = \sigma_T \text{Mdot}_w / 4 \pi m_p v R$
(where R is the radius of the flow)

Non-GR line $> 100 R_s$ so: $1 < \sigma_T \text{Mdot}_w c^2 / 4 \pi f m_p 200 GM$

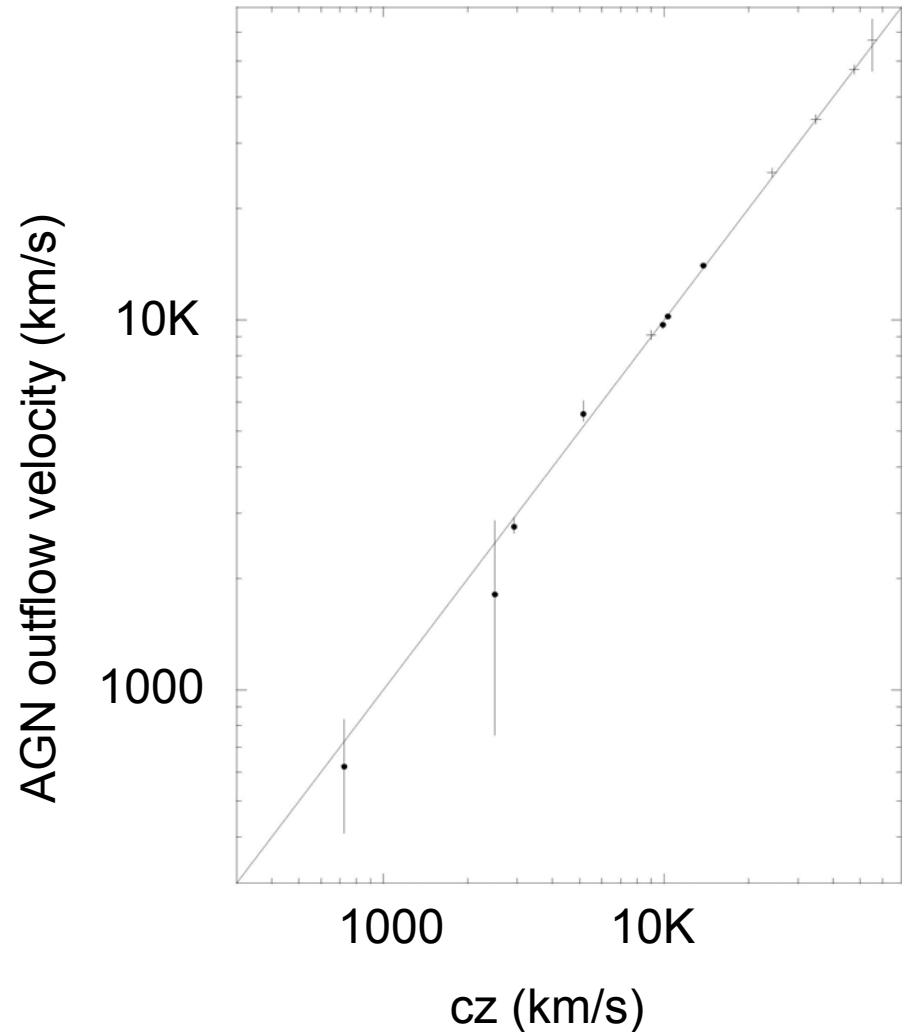
Recall: $L_{\text{Edd}} = 4 \pi GM m_p c / \sigma_T$

Therefore: $1 < \text{Mdot}_w c^2 c / 200 f v L_{\text{edd}}$

Then $\text{Mdot}_w / \text{Mdot}_a > 20 (\text{Mdot}_a / \text{Mdot}_{\text{Edd}})^{-1} f (v/c)$

And $f=1$, $v=0.3c$, so: $\text{Mdot}_w / \text{Mdot}_{\text{Edd}} > 6$

Absorption local to us, not the AGN



Relativistic lines in AGN, then and now. (see Nandra et al. 1997)

<u>ASCA lines “claimed”:</u>	<u>FWHM/σ(FWHM) > 2</u>	<u>XMM/CXO rel. lines</u>
Mrk 335	<u>Mrk 335</u>	Mrk 335
Fairall 9	Fairall 9	Fairall 9
3C 120	3C 120	3C 120 ???
NGC 3227	NGC 3227	NGC 3227
NGC 3516	NGC 3516	NGC 3516
NGC 3783	NGC 3783	NGC 4051
NGC 4051	NGC 4051	MCG-6-30-15
NGC 4151	NGC 4151	Mrk 766
Mrk 766	Mrk 766	NGC 5548
NGC 4593	NGC 4593	
MCG-6-30-15	MCG-6-30-15	IRAS 18325-5926
IC 4329A	IC 4329A	MCG-5-23-16
NGC 5548	NGC 5548	Q 0056-363
Mrk 841	Mrk 841	1H 0419-577
NGC 6814	NGC 6814	PG 1211+143
Mrk 509	Mrk 509	1H 0707-495
NGC 7469	NGC 7469	
MCG-2-58-22	MCG-2-58-22	

Relativistic lines in Galactic Black Holes

Prior to 1999

GX 339-4
Cygnus X-1
V404 Cyg ??

After 1999

GS 1354-645
4U 1543-475
XTE J1550-564
XTE J1650-500
GRO J1655-40
GX 339-4
SAX J1711.6-3808
XTE J1720-318
XTE J1748-288
V4641 Sgr
XTE J1859+226
XTE J1908+094
GRS 1915+105
Cygnus X-1
XTE J2012+381